SHORTER ARTICLES AND DISCUSSION

A NEGLECTED PAPER ON NATURAL SELECTION IN THE ENGLISH SPARROW

In referring to Professor Bumpus's paper, "The Elimination of the Unfit as Illustrated by the Introduced Sparrow, *Passer domesticus*,"[1] as neglected, I do not intend to imply that it is unique in this respect. Several other important quantitative studies of natural selection, for instance papers by Weldon, Di Cesnola and Pearson, are in the same class. Indeed, the impression gained by reading papers commemorating the birth of Darwin and the publication of the "Origin of Species by Means of Natural Selection" is that the majority of biologists have little interest in natural selection as a scientific problem. The chief reason for this is probably the great development of experimental breeding during the last decade—a development which is a great source of satisfaction to biologists, but which has temporarily brought the study of evolution to a very one-sided stage of development.

At the time this lecture was published the statistical methods which are now considered the most suitable for dealing with such problems were not in the hands of many biologists. Recently in connection with some other work I had occasion to throw Dr. Bumpus's data[2] into statistical constants. These are published in the hope that they may suggest to some unoccupied biologist the collection of further quantitative data on the several problems presented by the introduced sparrow.

The characters dealt with are the following: (1) Total length in millimeters from tip of beak to tip of tail; (2) alar extent, the distance in millimeters from tip to tip of extended wings; (3) weight in grams; (4) length of head in millimeters from tip of beak to the occiput; (5) length of humerus in fractions of an inch; (6) length of femur in fractions of an inch; (7) length of tibio-tarsus in fractions of an inch; (8) width of skull in fractions of an inch; (9) length of sternum in fractions of an inch.

[1] Eleventh lecture before the Marine Biological Laboratory, Woods Hole, 1898; published in Biological Lectures from the Marine Biological Laboratory, 1898. Boston, Ginn and Co., 1899.

[2] Fortunately all the measurements were published.

Three classes of birds were distinguished—adult males, young males, and young and adult females.

We draw the following conclusions from the comparison of the means in Tables I–III with their probable errors.[3]

TABLE I

AVERAGES FOR ADULT MALES

Character	Survived	Perished	Difference
Total length.....	159.0571±.3154	162.0000±.3253	−2.9429±.4531
Alar extent.....	247.6857±.4333	247.3750±.4716	+ .3107±.6404
Weight (in grams)	25.4685±.1420	26.2708±.1966	— .8023±.2424
Beak and head.....	31.6143±.0709	31.6708±.0824	— .0565±.1095
Length, humerus ...	.7380±.0022	.7279±.0032	+ .0101±.0038
Length of femur.....	.7168±.0025	.7061±.0027	+ .0107±.0037
Tibio-tarsus.	1.1353±.0041	1.1202±.0051	+ .0151±.0065
Width of skull.....	.6025±.0016	.6033±.0017	— .0008±.0023
Keel of sternum.....	.8576±.0042	.8458±.0045	+ .0118±.0062

TABLE II

AVERAGES FOR YOUNG MALES

Character	Survived	Perished	Difference
Total length.....	159.6875±.4978	162.2499± .7291	−2.5624± .8828
Alar extent.....	246.8125±.7936	247.9167±1.2976	−1.1042±1.5213
Weight (in grams).	25.4938±.2040	26.2667± .3208	— .7729± .3801
Beak and head.....	31.8688±.1190	31.3249± .1138	+ .5439± .1646
Length, humerus....	.7416±.0039	.7347± .0055	+ .0069± .0067
Length of femur.....	.7162±.0046	.7153± .0050	+ .0009± .0068
Tibio-tarsus	1.1367±.0091	1.1393± .0071	— .0026± .0115
Width of skull.....	.6078±.0024	.5993± .0035	+ .0085± .0042
Keel of sternum	.8514±.0060	.8427± .0064	+ .0087± .0088

TABLE III

AVERAGES FOR ALL FEMALES

Character	Survived	Perished	Difference
Total length.....	157.3810±.4774	158.4286±.4859	−1.0476±.6811
Alar extent.....	241.0000±.6009	241.5714±.7142	— .5714±.9333
Weight (in grams)..	24.6190±.153	25.3357±.2054	— .7167±.2561
Beak and head.....	31.4333±.1047	31.4786±.1068	— .0453±.1495
Length, humerus....	.7283±.0024	.7260±.0032	+ .0023±.0040
Length of femur.....	.7148±.0029	.7098±.0036	+ .0050±.0046
Tibio-tarsus.....	1.1436±.0042	1.1310±.0043	+ .0126±.0060
Width of skull.....	.6001±.0019	.6016±.0031	— .0015±.0036
Keel of sternum.....	.8193±.0043	.8207±.0037	— .0014±.0057

[3] For the individual comparisons those differences less than the probable error will be considered of no significance, those between one and two times their probable errors as possibly significant, and those over thrice their probable errors as probably significant.

TABLE IV

STANDARD DEVIATIONS FOR ADULT MALES

Character	Survived	Perished	Difference
Total length	2.7666±.2230	2.3629±.2300	+.4037±.3203
Alar extent	3.8005±.3064	3.4255±.3335	+.3750±.4529
Weight (in grams)	1.2451±.1004	1.4276±.1390	—.1825±.1715
Beak and head	.6220±.0501	.5982±.0582	+.0238±.0768
Length, humerus	.0196±.0016	.0230±.0022	—.0034±.0027
Length of femur	.0222±.0018	.0199±.0019	+.00 3±.0026
Tibio-tarsus	.0355±.0029	.0370±.0036	—.0015±.0046
Width of skull	.0317±.0011	.0123±.0012	+.0194±.0016
Keel of sternum	.0366±.0030	.0325±.0032	+.0041±.0044

TABLE V

STANDARD DEVIATIONS FOR YOUNG MALES

Character	Survived	Perished	Difference
Total length	2.9521±.3520	3.7444±.5155	— .7923± .6242
Alar extent	4.7066±.5612	6.6641±.9175	—1.9575±1.0755
Weight (in grams)	1.2101±.1443	1.6474±.2268	— .4373± .2687
Beak and head	.7060±.0842	.5847±.0805	+ .1213± .1166
Length, humerus	.0234±.0028	.0282±.0039	— .0048± .0048
Length of femur	.0272±.0032	.0258±.0035	+ .0014± .0047
Tibio-tarsus	.0537±.0064	.0365±.0050	+ .0172± .0081
Width of skull	.0141±.0017	.0180±.0025	— .0039± .0030
Keel of sternum	.0356±.0042	.0331±.0046	+ .0025± .0062

TABLE VI

STANDARD DEVIATIONS FOR ALL FEMALES

Character	Survived	Perished	Difference
Total length	3.2437±.3376	3.8119±.3436	— .5682±.4817
Alar extent	4.0825±.4249	5.6025±.5050	—1.5200±.6600
Weight (in grams)	1.0400±.1082	1.6112±.1452	— .5712±.1811
Beak and head	.7114±.0740	.8381±.0755	— .1267±.1054
Length, humerus	.0160±.0017	.0255±.0023	— .0095±.0029
Length of femur	.0197±.0021	.0279±.0025	— .0082±.0033
Tibio-tarsus	.0287±.0030	.0336±.0030	— .0049±.0042
Width of skull	.0128±.0013	.0245±.0022	— .0117±.0026
Keel of sternum	.0292±.0030	.0286±.0026	+ .0006±.0040

In all three series the individuals which survive are shorter than those which perish. The probable errors support in a very satisfactory manner the conclusion, "that when nature selects, through the agency of winter storms of this particular kind of severity, those sparrows which are short stand a better chance of surviving." For weight the results for the three series are also consistent in sign, and even when taken individually indicate

with a considerable degree of probability that the heavier birds are the least able to withstand the vicissitudes of the February sleet and snow. In all three series the length of the humerus is longer in the birds which survive, and in the group of adult males the difference is perhaps statistically significant. The same is true for the length of the femur, but the results are again insignificant except in the adult males where they are perhaps statistically trustworthy. In the adult males and in the adult and young females the length of the tibio-tarsus seems to be longer in the survivors, but the result is insignificant for the young males.

If selective elimination be a reality in nature one would not expect all of the characters of a series of individuals which perished when exposed to a given set of unfavorable conditions to differ from the same characters in the individuals which survive, and this for the simple reason that variations in many characters may not be of vital importance to the individual—in short, not of selective value.

The constants seem to me to justify no conclusion concerning the length of the sternum. For alar extent all three differences individually considered are insignificant; taken comparatively two are negative and one positive in sign. Apparently variations in the spread of wing have under the particular conditions[4] no significance in determining the chances of survival. The young males which survived have longer skulls (tip of beak to the occiput) than those which perished, and the difference seems to be significant in comparison with its probable error, but in the other two classes of birds the differences are not merely statistically insignificant but negative in sign.

Tables IV–VI show the standard deviations and their probable error. These are essential in calculating the probable errors of the means and in testing the hypothesis of a reduction in variability by selective elimination. Bumpus has discussed this question in detail in his lecture, but to me it seems that the standard deviations as given here do not justify any final conclusions concerning the relation of selection to variability: the problem is too complicated and the data are too few. As in other evolutionary problems we need more measurements. When these are available

[4] "Were the eliminative agent, for example, a severe northerly wind of protracted duration, the alar extent might then enter in as a factor of considerable selective value."

not only type and variability but correlation[5] will be open for investigation.

Looking at the tables of constants, the cautious biometrician will hesitate to say that Professor Bumpus has *proved* his point. The data available are too scanty to justify dogmatic assertions. But the work is so suggestive and the results so convincing that it is difficult to understand why zoologists have not followed it up by other studies of a comparable nature. To be sure, opportunities of this particular kind do not occur every winter, but there are other sources of elimination active in nature, and one of the most important tasks before those interested in the problems which Darwin pointed out to biologists, is to determine whether the individuals which survive are able to do so because of certain structural peculiarities, while those which perish are eliminated because they are in the degree of development or in the correlation of their parts structurally unfit.

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[5] Compare besides Bumpus's suggestion on this point, the arguments of Brooks in his "Foundations of Zoology," Lectures VI–VIII, and the hypothesis of Crampton, in *Journ. Exp. Zool.*, 2: 425–430, 1905.